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26 March 1958

MATERIAL - ZINC-TREATED MAGNESIUM -
METAL PLAING - PHYSICAL PROPERTIES
EVALUATION OF

Contract No. AF33(657)-7248

GENERAL DYNAMICS | FORT WORTH

CONVAIR
FORT WORTH

Department 6
FWP 2376 - 2 - 53

TEST DATA MEMORANDUM

F TDM NO. 1886
MODEL B-58
TEST NO. F-7228

TEST: MATERIAL - ZINC-TREATED MAGNESIUM - METAL PLATING - PHYSICAL PROPERTIES - EVALUATION OF

OBJECT: To investigate the physical properties of tin and tin-zinc alloy electroplates on Dow Chemical Co. zinc-treated HK-31 and AZ-31 magnesium alloys.

TEST SPECIMENS AND PROCEDURE: The specimens, materials and equipment used during this test are given in Table I. The magnesium specimens were zinc-treated by the Dow Chemical Co. prior to the application of platings at this facility. Specimens were cleaned and electroplated with 0.0005" of tin or tin-zinc alloy by the various procedures outlined in Tables II and III. Specimens were then visually examined for defective platings as outlined in Table IV. Specimens which exhibited no defects were given adhesion, heat cycling, and salt spray exposure tests according to the procedures listed in Table IV.

RESULTS: The results and visual evaluation of the various electroplating procedures are listed in Table V. The results of tests to evaluate the physical properties of platings produced by successful procedures are given in Table VI.

DISCUSSION: The suggested procedures outlined in the test request were followed but gave poor results. Certain deviations from those procedures were then made. These are listed in Table VII.

Table V shows that none of the procedures produced a successful electroplate on the AZ-31 alloy. It also shows attractive platings were obtained on the HK-31 alloy by Methods 6 and 7. Table VI shows that these platings exhibited excellent adhesion and thermal shock properties but poor salt spray resistance.

CONCLUSION: The physical properties of tin and tin-zinc alloy electroplates on Dow zinc-treated magnesium alloys were investigated. The results of this test lead to the following conclusions:

1) Dow zinc-treated AZ-31 alloy is not successfully electroplated by any of the procedures investigated.
2) Procedures 6 and 7 will produce attractive platings on HK-31 alloy that exhibit good adhesion and thermal shock properties.
3) The platings produced by these procedures exhibit poor corrosion resistance to salt spray.

The tests described in this report were conducted between 3 February 1958 and 13 March 1958.

WITNESS: McE[illegible]

DATE: 26 March 1958
JGW

BY W. L. Armstrong
CHECKED J. E. Hal[illegible]
APPROVED K E D[illegible]

TABLE I

MATERIALS AND EQUIPMENT

A. MATERIALS

ITEM	QUANTITY	USE	SOURCE
Dow Zinc-Treated HK-31 Magnesium-Thorium Alloy Coupons (FMS 0046) * **	16 Each 2.0"x 3.0"x .060"	Specimens	Dow Chemical Co.
Dow Zinc-Treated AZ-31 Magnesium Alloy Coupons (QQ-M-44a) *	18 Each 2.0"x 2.0" x .060"	Specimens	Dow Chemical Co.
Copper Strike Plating Solution	7.6 Liters	Strike Plating	Chem. Lab. Stock
Fluoborate Tin Plating Solution	7.6 Liters	Tin Plating	" " "
Tin Metal Anodes	1.0 Lb.	Tin Plating	" " "
80% Tin - 20% Zinc Plating Solution	4.0 Liters	Tin-Zinc Alloy Plating	" " "
80% Tin -20% Zinc Alloy Anodes	1.0 Lb.	Tin-Zinc Alloy Plating	" " "
Copper Plating Solution(Rochelle Salt)	7.6 Liters	Copper Plating	" " "
Copper Anodes	1 lb.	Copper Plating	" " "
Zinc Plating Solution	7.6 Liters	Zinc Striking and Plating	" " "
Methyl Ethyl Ketone (TT-M-261)	2.0 Liters	Specimen Cleaning	" " "
3M Masking Tape No. 250		**Adhesion Tests**	**Minnesota Mining and Manufacturing Co.**

*** Temper H24**
**** Convair specification FMS-0046 has the same requirements as MIL-M-26075 for the thickness used.**

TABLE I (Continued)

MATERIALS AND EQUIPMENT

B. EQUIPMENT

ITEM	USE	SOURCE
Electroplating Apparatus	Specimen Plating	Convair Built
Vapor Degrease Cabinet	Cleaning	" "
500°F Furnace	Thermal Heat Cycling	Bluc M. Electric Co. Blue Island, Ill.
Salt Spray Cabinet	Corrosion Environment	Industrial Filter and Pump Mfg. Co. Type CH-1 Chicago, Ill.
Standard Laboratory Equipment	As needed	Chem. Lab. Stock

TABLE II

CLEANING AND PLATING PROCEDURES

Specimens of Dow Zinc-Treated AZ-31 magnesium and HK-31 magnesium-thorium alloys were cleaned and plated as outlined below:

A. Specimen Cleaning:

1. Trichloroethylene vapor degrease for 3 minutes
2. Methyl Ethyl Ketone clean
3. Air dry at room temperature

B. Specimen Plating:

PROCEDURE NO.	SPECIMEN NUMBER ALLOY AZ-31	SPECIMEN NUMBER ALLOY HK-31	PLATING PROCEDURES (See Table III For Solution. Conc. And Operating Conditions)	PLATE THICKNESS (INCHES)
1	1	1	a. Copper Strike b. Tin Plate from Fluoborate Bath	.00001* .0005
2	2	2	a. Copper Strike b. 80% Tin-20% zinc Alloy Plate	.00001* .0005
3	3	3	a. Copper Strike b. Tin Plate from Sodium Stannate Bath	.00001* [illegible]
4	4 5	4 5	a. Copper Strike b. Copper Plate c. 80% Tin-20% Zinc Alloy Plate	.00001* .0001 .0005
5	6 7	6 7	a. Zinc Strike b. Copper Strike c. Copper Plate d. 80% Tin-20% Zinc Alloy Plate	.00001* .00001* .0001 .0005

TABLE II - (Continued)

B. Specimen Plating (Continued)

PROCEDURE NO.	SPECIMEN NUMBER ALLOY AZ-31	SPECIMEN NUMBER ALLOY HK-31	PLATING PROCEDURES (See Table III for Sol'n. Conc. and Operating Conditions)	PLATE THICKNESS (INCHES)
6	8 9 10	8 9 10	a. Zinc Strike b. Zinc Plate c. Copper Strike d. Copper Plate e. 80% Tin-20% Zinc Alloy Plate	.00001* .0001 .00001* .0001 .0005
7	11 12 13	11 12 13	a. Zinc Strike b. Zinc Plate c. Copper Strike d. Copper Plate e. Tin Plate From Sodium Stannate Bath	.00001* .0001 .00001* .0001 .0005

* Thickness Estimated

TABLE III

PLATING SOLUTION COMPOSITIONS AND OPERATING CONDITIONS

The procedures used during this test incorporated plating solutions having the following compositions and operating conditions:

1. COPPER STRIKE

Composition:

a. Copper Cyanide	3.0 oz/gal.
b. Sodium Cyanide	4.5 oz/gal.
c. Caustic Soda	0.25-0.50 oz/gal.
Anodes	Stainless Steel
Voltage	6 Volts
Temperature	Room Temperature
Strike Time	2 minutes

2. COPPER PLATE

Composition:

a. Copper Cyanide	3.5 oz/gal.
b. Sodium Cyanide	4.7 oz/gal.
c. Rochelle Salt	4.0 oz/gal.
d. Caustic Soda	0.5 oz/gal.
Anodes	Copper Metal
Temperature	Room Temperature
Current Density	0.1 amps/sq. in.

3. ZINC STRIKE AND ZINC PLATE

Composition:

a. Sodium Cyanide	5.0 oz/gal.
b. Zinc Cyanide	10.6 oz/gal.
c. Caustic Soda	15.0 oz/gal.
Anodes	Zinc Metal
Temperature	Room Temperature
Voltage (Strike)	3.0 volts
Voltage (Plate)	2.0 volts
Strike Time	3.0 minutes
Plate Time	15.0 minutes

TABLE III (Continued)

4. FLUOBORATE TIN PLATE

Composition:

a.	Stannous Fluoborate	200.0 gms/liter
b.	Fluoboric Acid	50.0 gms/liter
c.	Boric Acid	25.0 gms/liter
d.	Beta Napthol	1.0 gms/liter
e.	Gelatin	6.0 gms/liter
f.	Tin (by analysis)	80.0 gms/liter

Temperature	Room Temperature
Current Density (amps/sq. ft.)	25-125
Ratio of Anode to Cathode Area	2:1
Anode	Tin Metal

5. SODIUM STANNATE TIN PLATE

Composition:

a.	Sodium Stannate	105.0 gms/liter
b.	Sodium Hydroxide	9.0 gms/liter
c.	Sodium Acetate	15.0 gms/liter
d.	Tin (by analysis)	40.0 gms/liter

Temperature	150 ± 5°F
Current Density (amps/sq.ft.)	10-25
Ratio Anode to Cathode Area	1:1
Anodes	Tin Metal

6. 80% TIN - 20% ZINC ALLOY PLATE

Composition:

a.	Potassium Stannate	120.0 gms/liter
b.	Zinc Cyanide	9.0 gms/liter
c.	Potassium Cyanide	21.0 gms/liter
d.	Free Potassium Cyanide	6.5 gms/liter

Anodes	80% Tin, 20% Zinc Alloy
Ratio of Anode to Cathode Area	2:1
Temperature	150 ± 5°F
Voltage	3.5

TABLE IV

PLATE EVALUATION METHODS

VISUAL INSPECTION:

Before exposure to the test procedures given below, the plated specimens were visually inspected for pitting, blistering, burning, poor adhesion, and poor coverage of the plating. Specimens failing this preliminary examination were not subjected to further test procedures. These results are given in Table V.

MECHANICAL ADHESION TESTS:

One specimen from each successful plating procedure was tested for plate adhesion by the standard 3M 250 tape stripping test. This test was followed by probe examination and bending until fracture of the base material occurred. After fracture, the adhesion was checked at the interface of the electroplate and base material. Results of these examinations are given in Table VI.

THERMAL HEAT CYCLING:

One specimen from each successful plating method was tested to determine its resistance to thermal heat cycling. These tests were conducted by exposing the specimen to a temperature of 400°F for 3 minutes and then immediately immersing it in 70°F water. This cycle was repeated a total of 3 times, with specimens being examined for burning, blistering, or peeling of the plating. Results of this test are given in Table VI.

SALT SPRAY EXPOSURE:

Two specimens from each successful plating procedure were exposed to salt spray in accordance with Federal Test Method Standard 151, Method 811,* for 48 hours or until failure of plate, whichever occurred first. Following exposure, the specimens were visually examined for pitting, with more than 3 pits/sq." considered as failure of plate. These results are given in Table VI.

* 20% salt spray.

TABLE V

RESULTS AND VISUAL EVALUATION OF PLATING PROCEDURES

A. DOW ZINC-TREATED AZ-31 MAGNESIUM ALLOY

PLATING PROCEDURE	SPECIMEN	PLATING OBSERVATIONS	COVERAGE	PLATE CON-DITIONS	RESULTS
1.a. Copper Strike b. Fluoborate Tin Plate	1	High Fluoride Content Causes Speci-men Etching	Poor	Poor	Fail
2.a. Copper Strike b. Tin-Zinc Alloy Plate	2	Copper Strike not uniform	Poor	Poor	Fail
3.a. Copper Strike b. Sodium Stannate Tin	3	Copper Strike not uniform	Poor	Poor	Fail
4.a. Copper Strike b. Copper Plate c. Tin-Zinc Alloy Plate	4 & 5	Copper Plate gives fair coverage	Poor	Poor	Fail
5.a. Zinc Strike b. Copper Strike c. Copper Plate d. Tin-Zinc Alloy Plate	6 & 7	Copper Plate gives full coverage	Fair	Blistered	Fail
6.a. Zinc Strike b. Zinc Plate c. Copper Strike d. Copper Plate e. Tin-Zinc Alloy Plate	8,9& 10	Copper Plate gives full coverage	Good	Blistered	Fail
7.a. Zinc Strike b. Zinc Plate c. Copper Strike d. Copper Plate e. Sodium Stannate Tin	11,12 & 13	Copper Plate gives full coverage	Good	Blistered	Fail

TABLE V (Continued)

B. DOW ZINC-TREATED HK-31 MAGNESIUM-THORIUM ALLOY

PLATING PROCEDURE	SPECIMEN	PLATING OBSERVATIONS	COVERAGE	PLATE CONDITION	RESULTS
1.a. Copper Strike b. Fluoborate Tin Plate	1	Solution too acidic - specimen etches	Poor	Poor	Fail
2.a. Copper Strike b. Tin-Zinc Alloy Plate	2	Copper Strike is poor	Poor	Poor	Fail
3.a. Copper Strike b. Sodium Stannate Tin	3	Copper Strike not Uniform	Poor	Poor	Fail
4.a. Copper Strike b. Copper Plate c. Tin-Zinc Alloy Plate	4 & 5	Copper Plate Gives fair coverage	Poor	Blister-ed	Fail
5.a. Zinc Strike b. Copper Strike c. Copper Plate d. Tin-Zinc Alloy Plate	6 & 7	Copper Strike gives fair coverage	Fair	Blister-ed	Fail
6.a. Zinc Strike b. Zinc Plate c. Copper Strike d. Copper Plate e. Tin-Zinc Alloy Plate	8,9,& 10	Full Coverage after copper plate	Good	Ad-herent	Pass
7.a. Zinc Strike b. Zinc Plate c. Copper Strike d. Copper Plate e. Sodium Stannate Tin	11,12,& 13	Full Coverage after copper plate	Good	Ad-herent	Pass

TABLE VI
RESULTS OF PHYSICAL EVALUATION TESTS FOR TIN AND TIN-ZINC ALLOY ELECTROPLATED ON DOW ZINC-TREATED HK-31 MAGNESIUM

A. MECHANICAL ADHESION TESTS

PLATING PROCEDURE	SPECIMEN NO.	TYPE OF ADHESION FAILURE: TAPE STRIPPING	AFTER FRACTURE	PROBE EXAMINATION	RESULTS
#6 Tin-Zinc Alloy Plate	8	None	None	None	Pass
#7 Sodium Stannate Tin Plate	11	None	None	None	Pass

B. 400°F-TO-70°F THERMAL HEAT CYCLING TEST

PLATING PROCEDURE	SPECIMEN NO.	TYPE OF FAILURE: BLISTERING	BURNING	PEELING	RESULTS
#5 Tin-Zinc Alloy Plate	8	None	None	None	Pass
#7 Sodium Stannate Tin Plate	11	None	None	None	Pass

C. SALT SPRAY EXPOSURE TEST

PLATING PROCEDURE	SPECIMEN NO.	EXPOSURE TIME (HOURS)	CONDITION OF PLATE (PITS/SQ. INCH)	RESULTS
#6 Tin-Zinc Alloy Plate	9 & 10	4	40-60	Fail
#7 Sodium Stannate Tin Plate	12 & 13	4	40-60	Fail

TABLE VII

TABULATION OF DEVIATIONS FROM SUGGESTED PROCEDURES GIVEN IN TEST REQUEST

(1) The alkaline cleaning step was omitted to prevent contamination of the zinc-treated surfaces.

(2) The sodium stannate tin plating bath was used instead of the fluoborate bath. The latter was found to react with the specimens during the plating operation.

(3) The proposed copper strike undercoat methods produced very poor deposits. For this reason, smaller specimens were prepared and a wider selection of plating procedures was evaluated as shown in Tables V and VI.